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13. ABSTRACT (Maximum 200 words) Describes Dr. Andrey A. Voevodin's visit to Wright Laboratory, Wright-Patterson AFB, Ohio, between 1 - 11 June 1993. He briefed the activities of Tula State Technical University in surface modification and coating technology and deposition and study of coatings deposited from plasma fluxes in vacuum.				
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R E P O R T
O N S E M I N A R

Development of Wear Resistant Multilayer Coatings with
Diamond-Like Layers Produced by Pulsed Laser Deposition

Participants:

1. Research group of Dr.M.Donley - Materials Directorate of the Wright Laboratory, the WPAFB, Dayton, Ohio, the USA;
2. Dr.A.A.Voevodin - Laboratory of Electrophysical and Electrochemical Treatment, Department of Production of Machines and Apparatuses, Tula State Technical University, Russia.
3. Specialists from other research groups of the Wright Lab - pulsed laser deposition, electron scanning and transition microscoping, XPA and Raman spectrometer, stress analysis.

Place: The Wright Laboratory, Dayton, Ohio, the USA.

Duration and dates: 11 days - from 1nd to 11th June 1993.

Dr.A.A.Voevodin arrived to Dayton in the evening of the 1st June. On the 2nd June the necessary arrangements for his clearance to the Wright Laboratory were done and he was shortly acquainted with facilities of Materials Directorate/WL and its specialists.

On the 3rd June the work of the seminar began with the reports of Dr.A.A.Voevodin on the activity of the Tula State Technical University (T.S.T.U.) in surface modification and coating technology and on last achievements in deposition and studying of coatings deposited from plasma fluxes in vacuum. The results of recent work of Dr.A.A.Voevodin in deposition of wear reducing multilayer metal/ceramic coatings for piston rings of internal combustion engines caused interest from specialists of ML/WL and were discussed. The works of the T.S.T.U. in forming hard oxide-silicate coatings on aluminum based alloys by micro-arc treatment in electrolytes also aroused interest and were shortly discussed too.

The first days of the seminar were devoted to discussions of results in wear resistant vacuum coatings produced by TSTU and ML/WL and to experience exchanges in coating deposition from plasma fluxes created by arc (TSTU) and laser (ML/WL), as well as coating studying and their practical non-military applications. It was agreed that modern approach to antiwear coating development includes incorporation into the coating special friction reducing layers such as MoS (ML/WL) or porous TiN (TSTU), apart from hard layers. The problems in deposition of wear resistant diamond like carbon (DLC) layers were also outlined. To overcome nonsufficient adhesion and instability of such layers the special adhesive, stress reducing and diffusion barrier layers were proposed to be used. The experiments in pulsed laser deposition, laser annealing and studying of DLC specimens produced in ML/WL and TSTU were planned for the next week.

The end of the week was devoted to the culture programme: visit to local sights of interest, hosted by Dr.Joseph Davison - formerly on leave to BOARD, parties with members of Dr.Donley's tribology group and other people of Dayton. The discussions of life in Russia and USA took place and it greatly helped in understanding culture and tradition background, and establishing more close and mutually trustful relations.

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On 7th June (Monday) the seminar continued its work.

The research proposal in PLD of DLC-based coatings was made by Dr.Voevodin. After its discussion the proposal was accepted to be used in research project on wear resistant coating developed by Dr.Donley and his group. The discussion of the project concerned:

- modernization of deposition technique - alteration laser beam-target-substrate space orientation, supplying substrate with potential;

- development plasma microprobes - modified Langmuire probe, kinetical energy analysator, film growth monitoring;

- methods of coating testing and investigations - SEM, TEM, XPS and Raman spectroanalysis, nanoindentation tests, wear tests.

In discussions were also envolved scientits from electron diffraction and energy analysation group of ML/WL and pulsed laser deposition group of University of Dayton.

The mathematical models and software for process modelling and stress analysis developed by Dr.Voevodin were presented and considered to be involved in the project. Their necessary alterations for PLD specificatins were underlined.

Experiments in PLD production of DLC films were run and then the comparasion studies of DLC fims, produced by PLD (ML/WL) and by arc evapoartion (TSTU) were performed. Raman spectra of both as-grown speciements didn't show separate diamond or graphite peaks, due to their amorphous structure. However, after laser annealing the PLD produced film had more crystalline structure then the arc deposited film. PLD process was considered as more perspective one for wear resistant DLC film growing, inspite on its lower deposition rate. Ways to increase film growing rate and produce more fine grained films were discussed.

The general plan for the collaborative researches in PLD of DLC-based multilayer coatings was accepted. The financial support for project performing is now seeking for. One of the possible sources for such support is the NRC of the USA. Dr.Voevodin is now proceeding documents for the NRC support.

It was emphasized that the more detailed aquaintance of scientists of Dr.Donley's group with last achievements of russian scientists in DLC technology in Tula, Moscow, Kharkov and S.-Peterburg would greatly help in project further development and enhance its effectivity. For this purpose the visit of Dr.M.S.Donley and his colleague Dr.J.Zabinski to research institutes in Russia and Ukriana was preliminary planned (see appendix). The arrangements for this scientists to visit Russia and Ukraina research centres in DLC deposition and tribology is now processing by Dr.Voevodin. To do the visit the financial support for these scientists is needed.

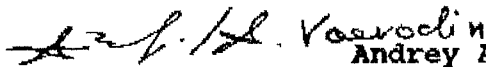
In the end of the seminar Dr.Voevodin had meetings with director of Materials Directorate Dr.V.Russo and Commander of Wright Laboratory Colonel D.Herrelko. The proposals and projects of agreement for wide scientific collaboration between TSTU and Wright Laboratory were transfered by Dr.Voevodin on behalf of the tsru authorities and discussed. These documents are now under further consideration, and mutually benefit collaboration between athorities and scientists of both institutes and participation in international research programmes is expected.

Dr.Voevodin also visited officials of University of Dayton with proposal from the TSTU to start collaboration not only in researches but also in student education and research staff

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Results of the seminar:

1. The presentations of research activities of TSTU and WL in coating technology and exchanges of research experiences were done.
2. The collaborative research project in pulsed laser deposition of multilayer wear resistant coatings with DLC layers was developed and detalised. Problems to be solved were outlined, methodology and methods of researches were developed.
3. Plans for scientific collaboration in materials science and tribology were concretized for near future: i) short visit of Drs. Donley and Zabinski to Russia and Ukraine research centres; ii) collaboartive researches in PLD of DLC. Provide the necessary financial support is found, these plans will be put into life in the beginning of 1994.
4. General agreement for wide scientific collaboartion between TSTU and WL was put on the agenda and is expected to be developed.
5. The direct contacts between scientists of TSTU and ML/WL based on mutual understanding and confidence were established.



Andrey A. Voevodin
TSTU, Tula, Russia
18 June 1993

Appendix

OUTLINE OF VISIT
of Dr.M.Donley and Dr.J.Zabinski
from Materials Directorate / Wright Laboratory
to research centres in Russia and Ukraina
engaged in DLC deposition and tribology studies

The purposes of the Visit:

1. Acquaintance with results of investigations of diamond and diamond-like films produced by different methods in Russia and Ukraina research centres.
2. Beginning research collaboration between scientists of the Wright Laboratory and Russian and Ukrainian scientists from a number of institutes.
3. Enhancing of the international collaborative research project in the wear resistant DLC-based multilayer coatings on the base of the latest achievements in DLC deposition and tribology in research centres of Russia and Ukraina.

Suggested duration and dates: 18 days, February - March

Cities to be visited: Tula, Moscow, S.-Peterburg (Russia), Kharkov (Ukraine).

General host, guide and interpreter: Dr.A.A.Voevodin, TSTU, Tula. (for all days of the visit).

1st day (Friday). Moscow-Tula

Arrive to Moscow in the morning, meet by Dr.Voevodin in Moscow airport. Arrive to Tula in the afternoon, country clearance and lodging at the Tula State Technical University camp.

2nd and 3d days (Saturday and Sunday). Tula

Acclimatization days and culture programmes to the local points of interest.

4th day (Monday). Tula

- University laboratories clearance;
- acquaintance with the Laboratory of Electrophysical and Electrochemical Treatment of the TSTU;
- meeting with professor V.V.Lyubimiv, head of the Laboratory;
- discussion results of the Laboratory in wear resistant coatings produced by the arc evaporation with layers of ceramic, metal, DLC;
- experience exchange in vacuum plasma deposition and discussion possible ways for improvement process parameters and DLC film properties.

5th day (Tuesday). Tula

- visit to the Materials Department of the TSTU, experience exchange in tribology studies;
- meetings and problems discussions with professor S.A.Golovin, head of Department, and professor V.M.Vlasov, chief of tribology group;
- presentation of works of the Materials Directorate / WL in wear resistant and antifriction coatings, produced by the pulsed laser deposition;